IN THE CLAIMS:

Please cancel claims 1-40 without prejudice or disclaimer.

REMARKS

This is a division of Application No. 09/425,015 filed October 25, 1999, which is still pending.

In response to a Written Restriction Requirement in the parent application, Applicants elected claims 1-40 for prosecution.

This divisional application is filed to pursue the subject matter of the non-elected claims 41-44.

Early consideration of the claims presented in this Preliminary Amendment and issuance of Notice of Allowance are earnestly requested.

Applicants' undersigned attorney may be reached in our New York office by telephone at (212) 218-2100. All correspondence should continue to be directed to our address given below.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE TO SPECIFICATION

The paragraph starting at page 3, line 16 and ending at page 4, line 1 has been amended as follows:

--The present invention has been accomplished in view of the above problem and an object of the present invention is to provide a gas supply path structure (and a gas supply method) that can suppress occurrence of the shock wave while forming the gas flow at high speed close to the [sound] speed of sound in simple structure. A further object of the present invention is to provide a laser oscillating apparatus with long emission time equipped with the gas supply path structure, an exposure apparatus with high performance equipped with the laser oscillating apparatus, and a method for producing a high-quality device by use of the exposure apparatus.

The paragraph starting at page 4, line 11 and ending at page 4, line 12 as been amended as follows:

a throat portion for controlling said compressible fluid to a speed less than a [sound] speed of sound;

The paragraph starting at page 5, line 26 and ending at page 5, line 27 has been amended as follows:

--a predetermined portion for controlling said compressible fluid to a speed less than a [sound] speed <u>of sound</u>;

The paragraph starting at page 6, line 19 and ending at page 6, line 21 has been amended as follows:

--a step of controlling said compressible fluid to a speed less than a [sound] speed <u>of sound</u>, at a throat portion of said compressible fluid supply path structure;

The paragraph starting at page 7, line 12 and ending at page 7, line 15 has been amended as follows:

--a step of controlling said compressible fluid to a speed less than a [sound] speed <u>of sound</u>, at a predetermined portion of said compressible fluid supply path structure;

The paragraph starting at page 8, line 12 and ending at page 8, line 13 has been amended as follows:

--a throat portion for controlling said laser gas to a speed less than a [sound] speed <u>of sound</u>; and

The paragraph starting at page 10, line 8 and ending at page 10, line 9 has been amended as follows:

--a central part for controlling said laser gas to a speed greater than a [sound] speed <u>of sound</u>; and

The paragraph starting at page 12, line 1 and ending at page 12, line 2 has been amended as follows:

--a throat portion for controlling said laser gas to a speed less than a [sound] speed <u>of sound</u>; and

The paragraph starting at page15, line 25 and ending at page 16, line 2 has been amended as follows:

--Fig. 12 is a diagram to show the relation of conditions to gas velocity, Mach number, gas pressure, gas density, gas temperature, and [sound] speed <u>of sound</u> at each of <u>the</u> portions (fluid inlet, light emission portion, fluid outlet) of the gas supply path structure;

The paragraph starting at page 18, line 15 and ending at page 19, line 13 has been amended as follows:

--The gas supply path structure 11 is a nozzle which forms a flow path for allowing the laser gas to flow thereinto or out thereof through a pair of inlet/outlet ports11a, which is shaped so as to be narrowest at the central part, and which controls the

laser gas to a predetermined speed less than the [sound] speed <u>of sound</u> (the predetermined speed will be referred to as subsonic speed) at the central part as described hereinafter. Note that a speed greater than the [sound] speed <u>of sound</u> will be referred to as supersonic speed. Here the central part, where the flow velocity of the laser gas reaches the subsonic speed, serves as a light emitting portion 21 for emitting the laser light. As illustrated in Fig. 3, a pair of reflecting structures 22, 23, which are mirrors, prisms, or the like, are provided above and below this light emitting portion 21 in the figure and these reflecting structures 22, 23 function to align the phase of the light emitted from the light emitting portion 21 to generate the laser light. In the present embodiment the laser gas flows in two directions, i.e., to the left and to the right, in the gas supply path structure 11 and, therefore, the gas supply path structure 11 is symmetric with respect to the center. One of the inlet/outlet ports 11a serves as a fluid inlet and the other as a fluid outlet, depending upon the direction of the gas flow.

The paragraph starting at page 20, line 4 and ending at page 20, line 19 has been amended as follows:

--The waveguide tube 12 is a means for supplying a microwave to the laser gas in the gas supply path structure 11 and a plurality of elongate<u>d</u> slots are formed in the bottom portion. When the microwave is guided from the upper part of the waveguide tube

12, the microwave propagates in the waveguide tube 12 to be radiated through the slots 24 to the outside of the waveguide tube 12. The microwave thus radiated is guided through the slots 24 provided in the gas supply path structure 11 into the gas supply path structure 11. The microwave thus guided into the gas supply path structure excites the laser gas in the supply path structure 11 to generate the excimer laser light. A RF (radio-frequency) preionization discharge electrode 30 is provided in each of low-conductance portions 27 described hereinafter.

The paragraph starting at page 21, line 8 and ending at page 21, line 25 has been amended as follows:

--Eq. (1) is the equation of continuity, Eq. (2) the Bernoulli equation of the isentropic flow, Eq. (3) the adiabatic law of perfect, ideal gas, and Eq. (4) the equation of state of perfect, ideal gas. In these equations ρ represents the density, P the pressure, v the velocity, T the temperature, and A the cross-sectional area. The meanings of subscripts are defined as follows; a character without any subscript represents a value at an arbitrary point in the gas supply path structure 11, a character with subscript "in" a value at the fluid inlet, a character with subscript "out" a value at the fluid outlet, a character with subscript "throut" a value at the throat portion, and a character with subscript "*" a value at a virtual critical point at which the velocity of the gas flow becomes equal to a local [sound] speed <u>of sound</u>. Further, γ represents a ratio of specific heats, V the volume, n the number of moles, and R the gas constant.

The paragraph starting at page 22, line 6 and ending at page 22, line 17 has been amended as follows:

--In this structure, when the speed of the gas flow at the throat portion 21 reaches a speed greater than the [sound] speed <u>of sound</u>, there almost always occurs the shock wave at the fluid outlet. In the present embodiment a ratio of pressures at the fluid inlet and at the fluid outlet of the gas in the gas supply path structure 11 is kept not less than a ratio of critical pressures determined by P_{out}/P_{in} satisfying Eq. (5) so that the velocity of the gas at the throat portion 21 becomes the subsonic speed. Namely, the following relation holds where P'_{out} indicates an actually set pressure at the fluid outlet.

The paragraph starting at page 22, line 26 and ending at page 23, line 17 has been amended as follows:

--(Amended) Fig. 5 is a characteristic diagram to show the relation between (cross-sectional area of the fluid outlet/cross-sectional area of the throat portion) and (pressure at the fluid outlet/pressure at the fluid inlet). Since the excimer laser gas is composed mostly of monoatomic gas, the ratio of specific heats γ is assumed to be 5/3. It is a matter of course that an average ratio of specific heats may also be used. Referring to Fig. 5, for example, supposing that the height at the fluid outlet (the vertical width of the fluid outlet) is double the height of the throat portion 21 (the vertical width of the narrowest

part) (i.e., supposing a ratio of spatial cross-sectional areas of them is 2), the speed of the gas flow will not exceed the [sound] speed <u>of sound</u>, so as not to cause the shock wave, when the pressure at the fluid outlet is not less than about 0.93 times the pressure at the fluid inlet. For reference the gas speed at the throat portion 21 in the critical state is the [sound] speed <u>of sound</u>.

The paragraph starting at page 23, line 18 and ending at page 23, line 24 has been amended as follows:

--The [sound] speed <u>of sound</u> of the gas is a function of gas temperature. In the case of the KrF excimer laser gas, for example, supposing that a mixture ratio of gases is Ne:Kr:F_2 = 94.9:5:0.1 and assuming that the mixed gas is an ideal gas having the mean molecular weight M (Ne:20.18/Kr:83.8/F_2:38) of 23.4, the [sound] speed <u>of sound</u> a is expressed by the following equation.

The paragraph starting at page 23, line 26 and ending at page 24, Table 1 as been amended as follows:

--(Amended) Therefore, the [sound] speed <u>of sound</u> at each temperature is given by Table 1 below.

TABLE 1

Gas temperature		[Sound] speed of sound
°C	K	m/sec
-100	173.15	320.4
0	273.15	402.4
25	298.15	420.4
100	373.15	470.3
200	473.15	529.6
300	573.15	582.9

The paragraph starting at page 24, Fig. 6 and ending at page 25, line 3 has been amended as follows:

--Fig. 6 shows the relation of the conditions to the velocity, Mach number, gas pressure, gas density, gas temperature, and [sound] speed of sound at each of the portions (fluid inlet, throat portion, fluid outlet) of the gas supply path structure 11.

The paragraph starting at page 25, line 25 and ending at page 26, line 5 has been amended as follows:

--If in the shape of the gas supply path structure 11 there exists an inflection point such as sudden expansion or sudden contraction or the like, there is a possibility that

a region at or over the [sound] speed <u>of sound</u> is formed in a portion except for the throat portion 21. Therefore, the gas supply path structure 11 is desirably shaped so as to expand (or contract) relatively gently without a suddenly expanding portion.

The paragraph starting at page 33, line 3 and ending at page 33, line 14 has been amended as follows:

--Conversely, the preliminary heating of the laser gas is effective to increase of [sound] speed <u>of sound</u>. However, heating, particularly, of the throat portion 21 (also including heating due to the microwave) should better be avoided, because a choke phenomenon (an apparent decrease of cross-sectional area due to heating) occurs so as to make it difficult to satisfy the designed gas flow rate, though it contributes to the increase of the gas velocity. When this problem due to the heating is pronounced, the operating pressure of the bellows pumps 25 should be changed, because it changes the substantial ratio of cross-sectional areas.

The paragraph starting at page 36, line 8 and ending at page 36, line 24 has been amended as follows:

--As described above, the excimer laser oscillating apparatus of Modification 1 uses the paired gas supply path structure group 31 of the

convergent-divergent nozzle type in the laser chamber 1 and is arranged to adjust the pressure and velocity of the gas at the inlet and/or at the outlet, so that it can control the velocity of the excimer laser gas in the light emitting portion 32 to the predetermined supersonic speed while suppressing the occurrence of the shock wave, which can occur under almost all the conditions over the [sound] speed <u>of sound</u>. Therefore, the gas supply path structure group can be replenished quickly with the excimer laser gas, which is apt to be exhausted, without concern about the occurrence of the shock wave. Modification 1 can also realize the excimer laser oscillating apparatus that can maintain the stable light emission over a long time.

The paragraph starting at page 38, line 23 and ending at page 39, line 11 has been amended as follows:

--As described above, the excimer laser oscillating apparatus of Modification 2 employs the gas supply path structure 41 having the constant height in the laser chamber 1 and is arranged to adjust the pressure and velocity of the gas at the inlet and/or at the outlet, so that it can control the velocity of the excimer laser gas in the light emitting portion to the predetermined supersonic speed, while suppressing the occurrence of the shock wave, about which concern grows with proximity to the [sound] speed <u>of sound</u>. Therefore, the gas supply path structure group can be replenished quickly with the

excimer laser gas, which is apt to be exhausted, without concern about the occurrence of the shock wave. The present modification can also realize the excimer laser oscillating apparatus that can maintain the stable light emission over a long time.

The paragraph starting at page 40, line 8 and ending at page 40, line 23 has been amended as follows:

--As described above, the excimer laser oscillating apparatus of Modification 3 employs the gas supply path structure 11 of the convergent-divergent nozzle type in the laser chamber 1 and is arranged to adjust the gas pressure and the gas velocity at the inlet and/or at the outlet, so that it can control the velocity of the excimer laser gas in the throat portion to the predetermined subsonic speed while suppressing the occurrence of the shock wave, about which concern grows with proximity to the [sound] speed <u>of sound</u>. Therefore, the gas supply path structure can be replenished quickly with the excimer laser gas, which is apt to be exhausted, without concern about the occurrence of the shock wave. The present modification can also realize the excimer laser oscillating apparatus that can maintain the stable light emission over a long time.

The paragraph starting at page 46, line 19 and ending at page 47, line 2 has been amended as follows:

--The present invention makes it possible to provide the gas supply path structure (and the gas supply method) capable of suppressing the occurrence of the shock wave while forming the high-speed flow close to the [sound] speed of sound in the simple structure. Particularly, when this gas supply path structure is applied to the excimer laser oscillating apparatus, the apparatus can be replenished with the excimer laser gas, which is apt to be exhausted, without concern about the occurrence of the shock wave, and the apparatus can maintain the stable light emission over a long time.

VERSION WITH MARKINGS SHOWING THE CHANGES MADE TO CLAIMS

41. (Amended) An exposure apparatus comprising:

(i) a laser oscillating apparatus, said laser oscillating apparatus generating illumination light,

said laser oscillating apparatus [comprising] including a gas supply path structure having a convergent-divergent nozzles, [for supplying a laser gas,] said gas supply path structure [being of a convergent-divergent nozzle type, said gas supply path structure comprising:] having a fluid inlet into which a [said] laser gas is made to flow[;], a throat portion for controlling a flow speed of said laser gas to [a speed] less than a [sound] speed of sound[;] and a fluid outlet of which said laser gas from said throat portion is made to flow out and a waveguide unit for guiding microwaves into said gas supply structure;

(ii) a first optical system for radiating said illumination light from said laser oscillating apparatus onto a reticle in which a predetermined pattern is formed; and

(iii) a second optical system for radiating said illumination light having passed through said reticle, onto a surface to be irradiated.

42. (Amended) An exposure apparatus comprising:

(i) a laser oscillating apparatus, said laser oscillating apparatus generating illumination light,

said laser oscillating apparatus [comprising] including a gas supply path structure group [for supplying a laser gas, said gas supply path structure group being of a shape comprised of gas supply path structures] which has a plurality of [a] convergent-divergent [nozzle type connected in series,] nozzles, each nozzle comprising

[said gas supply path structure group comprising:]

a fluid inlet into which [said] laser gas is made to flow[;], a throat portion [a central part] for controlling a flow speed of said laser gas, [to a speed greater than a sound speed of sound;] and a fluid outlet of which said laser gas from said throat portion is made to flow out, and a waveguide unit for guiding microwaves into said gas supply path structure gropup, wherein said gas supply structure group includes a light emitting portion for generating a laser beam, and the flow speed of said laser gas at said light emitting portion is higher than a speed of sound;

(ii) a first optical system for radiating said illumination light from said laser oscillating apparatus onto a reticle in which a predetermined pattern is formed; and

(iii) a second optical system for radiating said illumination light having passed through said reticle, onto a surface to be irradiated.

43. (Cancelled)

44. (Cancelled)